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A Parallel Additive Schwarz Preconditioner for the Poisson Equation Based on an SIP Subdomain Solver

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ABSTRACT

The most computationally challenging part of solving the incompressible Navier-Stokers equations using fractional step methods is the pressure equation which is formed as a Poisson equation with the divergence of velocity as a source term. Therefore, developing a simple, efficient, scalable and robust Poisson solver has been one of the key research areas for decades in Computational Fluid Dynamics. In this paper, we discuss a fully parallelised Poisson equation on a cluster of processors by message passing, using a second-order central finite difference method on a structured staggered grid. The additive Schwarz domain decomposition method is adopted to avoid the use of global gather and scatter operations and to minimise the effect of communication bandwidth. Two preconditioning techniques, the Jacobi and the Strongly Implicit Procedure (SIP), are constructed based on the local grid partition. The resulting preconditioned Poisson equation is solved by the biconjugate gradient stabilized method. Performances in one, two and three dimensional decompositions are compared and analysed in detail. Our results show that the SIP precondtioner yields good convergence and is more robust than the Jacobi preconditioner with respect to the grid size and the number of processors.

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